UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Project	Date	Author

TITLE

PROGRESS REPORT

on

AN EXPERIMENT IN THINNING PONDEROSA PINE - WHITE FIR POLE STANDS TO CONTROL MOUNTAIN PINE BEETLE

Charles B. Eaton
Berkeley, California
March 24, 1939

U. S. GOVERNMENT PRINTING OFFICE 8—9742

SUBJECT—

INDEX NO.—

Forest Insect Laboratory
Berkeley, California
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AN EXPERIMENT IN THINNING PONDEROSA PINE - WHITE FIR POLE STANDS TO CONTROL MOUNTAIN PINE BEETLE

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PROGRESS REPORT ON AN EXPERIMENT IN THINNING PONDEROSA PINE - WHITE FIR POLE STANDS TO CONTROL MOUNTAIN PINE BEETLE*

INTRODUCTION

One of the indirect and less spectacular results of losses caused by certain forest insects in stands of mixed composition is the conversion of the forest type from species which are economically desirable to species which are inferior. This effect is well illustrated in certain stands of second growth ponderosa pine - white fir poles occurring on the Fandango Logging Chance in the Warner Mountains of northeastern California, where continued attacks by the mountain pine beetle (Dendroctonus monticolae Hopk.) have depleted the pine to the point where the fir is now the predominant species.

Forest type conversion resulting from the activity of this insect has been going on for some time, but thus far has proved to be indigenous to this particular locality. While the infestation type may prove to be unique among other infestation types in the California region, it is also possible that similar injury will occur in other areas of good site quality where logging activity has resulted in the removal of the light overstory of overmature trees, and thickets of mixed pine and fir have taken over the site. Since it is a well recognized fact that second growth stands will constitute the forest of the future, it is essential that some recognition be given to their present and future composition. This consideration brings to mind a number of questions: (1) Are the present mixed stands made up of desirable species? (2) Under natural conditions what species will be favored in future stand development? (3) If it appears that under natural conditions undesirable species will eventually occupy the site, what measures can be taken to favor the more valuable species?

In an attempt to develop answers to questions of this nature specifically pertinent to the problem now existing in the Fandango area, investigations were begun this season in the pine - fir pole type to determine the extent of damage by mountain pine beetle, and to test the value of silvicultural methods for indirectly controlling the insect in stands which have thus far been free from injury.

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* This project was conducted by the Division of Forest Insect Investigations of the Bureau of Entomology and Plant Quarantine in cooperation with the Forest Service. Field activities were centered on the Fandango Logging Chance in the North Warner District of the Modoc National Forest. The investigations reported herein were made by the writer with the assistance of W. L. Howe during the field season. Acknowledgments are due Dr. R. C. Hall for suggestions in the design of the thinning experiment, and Dr. K. A. Salman for general supervision of the work.

HISTORY OF MIXED STANDS IN THE FANDANGO AREA

Stand Condition

The appearance of the present forest cover in this region furnishes some clue to its past history. Over the general area in which ponderosa pine and white fir occur together in natural state the stand is typically two-storied, having a sparse old growth of widely scattered, overmature trees, beneath which occur dense stands of young growth of pole size. The old growth is predominantly ponderosa pine, whereas the young growth usually contains a high percentage of fir.

Exactly how this condition was brought about has not been conclusively proven. The presence of past losses and the current activity of the Dendroctonus brevicomis - Melanophila californica complex suggest the cause of the scattered distribution of the overmature ponderosa pine. At the present time logging activity is rapidly reducing this old growth to the point where it forms a very minor part of the stand.

The predominant part of the forest cover in the Fandango area is the young growth of mixed pine and fir, exemplifying intensive competition between tree species in the younger growing stages. The origin of these stands is not easily explained. In some localities there is definite evidence that they became established on old burned areas, while in other localities the sequence is not so apparent. At the present time these stands may be considered locked as far as development is concerned. Unlocking and return to normal growth may have been attained in the past through thinning by either fire or insects. In theory, at least, light fires would tend to favor the pine ofer the fir, since young age classes of the latter species are somewhat more susceptible to fire injury. However, there have been no light fires in these stands within the past half or three-quarters of a century. Proof that mountain pine beetle is capable of bringing about similar type conversion can be found in stands now present in the Fandango area, but in this case insect activity tends to eliminate the more valuable pine with the result that fir occupies the site. Since there is little evidence that insects will remove the competing fir in these pole stands, it becomes necessary to resort to silvicultural methods to secure a predominance of pine in the future timber crop.

Records

Notes in the files of the Berkeley station on mountain pine beetle activity in ponderosa pine - white fir stands in the North Warner Mountains cover a period of nearly two decades. The infestations were first reported in 1920 by J. M. Miller. In his report of that year, Miller mentioned the fact that attacks by this insect were apparently confined to local centers of 100 to 200 acres in fairly heavy pole stands of

second growth located on old burns.

Examining these same areas in 1921 and 1922, F. P. Keen attributed the mountain pine beetle attacks to the weakening of the pine through competition with the fir.

K. A. Salman found the infestations active on a much smaller scale in examinations made in 1932 and again in 1937. Concluding that ponderosa pine poles had been completely wiped out over a fairly large area during the period in which mountain pine beetle has been active in these stands, Salman recommended that an experiment should be set up in which the competing fir would be removed to release the pine from excessive competition. The object would be to produce a more thrifty stand of pine, presumably less susceptible to attack by this insect than the slower growing trees present under natural conditions.

SURVEY OF MOUNTAIN PINE BEETLE ACTIVITY

In the latter part of May, 1938, a general reconnaissance was made of mixed stands of ponderosa pine - white fir poles in the Fandango Logging Chance. Following the reconnaissance, a type survey was made in this area for the purpose of locating and mapping: (1) areas in which high past losses of ponderosa pine have occurred; (2) areas in which current infestations of mountain pine beetle exist; (3) areas in which losses in pine have not yet occurred. Samples were then taken in each of these areas to determine the relative proportion of pine and fir and the extent of losses of each species.

Methods

In making the type survey a series of cruise lines was run through the area, using a staff compass, Abney hand level, and 2 chain tape. These lines were usually spaced ½ mile apart, and were tied into the General Land Office survey system. For this work a two man crew proved satisfactory. One man acted as compassman and head chainman, while the second man acted as rear chainman and mapper. In view of the fact that the personnel available was limited, and because a fairly reliable Forest Service type map had already been constructed, it was not considered essential to make as intensive a survey in this study as would be necessary in a virgin area. For these reasons the customary strip cruise along each line was omitted. Instead, a field map was carried on which was noted:

1. Location of strip
2. Timber type
3. Stand maturity (reproduction, poles, mature, overmature)
4. Loss in pine (none, light, moderate, severe)
   a. Current
   b. Past

At the completion of the survey this information was used together with the Forest Service type map to construct a master map of the Fandango Logging Chance showing pine - fir pole stands classified according to degree of loss in pine. The following classifications were used: (1) areas of high past loss; (2) areas of high current loss; (3) susceptible areas.

In the sampling work which followed the type survey, strips ½ chain wide were run through stands representing each of these three degrees of loss, and a tally was made of living and dead trees. In the tally all trees were segregated by species, by 2 inch D.B.H. classes above 3 inches. Dead pines were classified as current losses (trees having fading or red foliage) and past losses (snags and sound down trees). Current and past losses in fir were lumped together. These data later served as a basis for compiling tables showing stand and loss per acre.

Results

A total of 8640 acres, including parts of the Cold Creek, Lassen Creek and Willow Creek watersheds (figure 1) were covered in the survey. Of this area 2140 acres were originally covered by mixed stands of ponderosa pine and white fir. In general this mixture (figure 2) is most common on good sites at elevations between 5500 and 6500 feet, with pure stands of pine at the lower levels and pure fir higher up. On the north and east slopes the fir occurs more abundantly than on the south and west slopes where pine predominates.

In individual stands the pines are usually the dominant trees, though height may vary considerably. Analysis of increment cores indicate that the trees are even-aged in groups, and that both species became established at practically the same time. Growth rate, particularly for the pine in the denser stands, is at a very low level.

Stands in which ponderosa pine and white fir originally occurred in mixture, and in which the former species has been practically entirely killed off by mountain pine beetle (figure 3) were found on 598 acres. Stands having high current loss in pine where this insect has been particularly active in recent seasons, occupied 54 acres. Stands in which pine and fir now occur cover an area of 1488 acres. Summaries of stocking and loss in each of these three areas are presented in tables 1, 2, and 3. The losses listed in these tables include current and past kills for pine and total kill for fir. An analysis of increment cores taken from trees released at the time of death of the pine indicates that past losses extend over a period of 15 to 20 years. Current losses include trees killed during the last two seasons.

FIGURE 1

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

PINE – FIR POLE AREAS
FANDANGO LOGGING CHANCE

MODOC NATIONAL FOREST, CALIFORNIA

SCALE
1/4 0 1/4 1/2 3/4 1 MILE

DECLINATION: 20° EAST
MAPPED 1938 C. B. EATON

LEGEND

AREAS OF LOSS IN PINE.
- HIGH CURRENT
- HIGH PAST
- SUSCEPTIBLE

- INTERMITTENT STREAM
- TYPE BOUNDARY
- THINNING PLOT
- UNMERCHANTABLE TIMBER
- TRUCK TRAIL

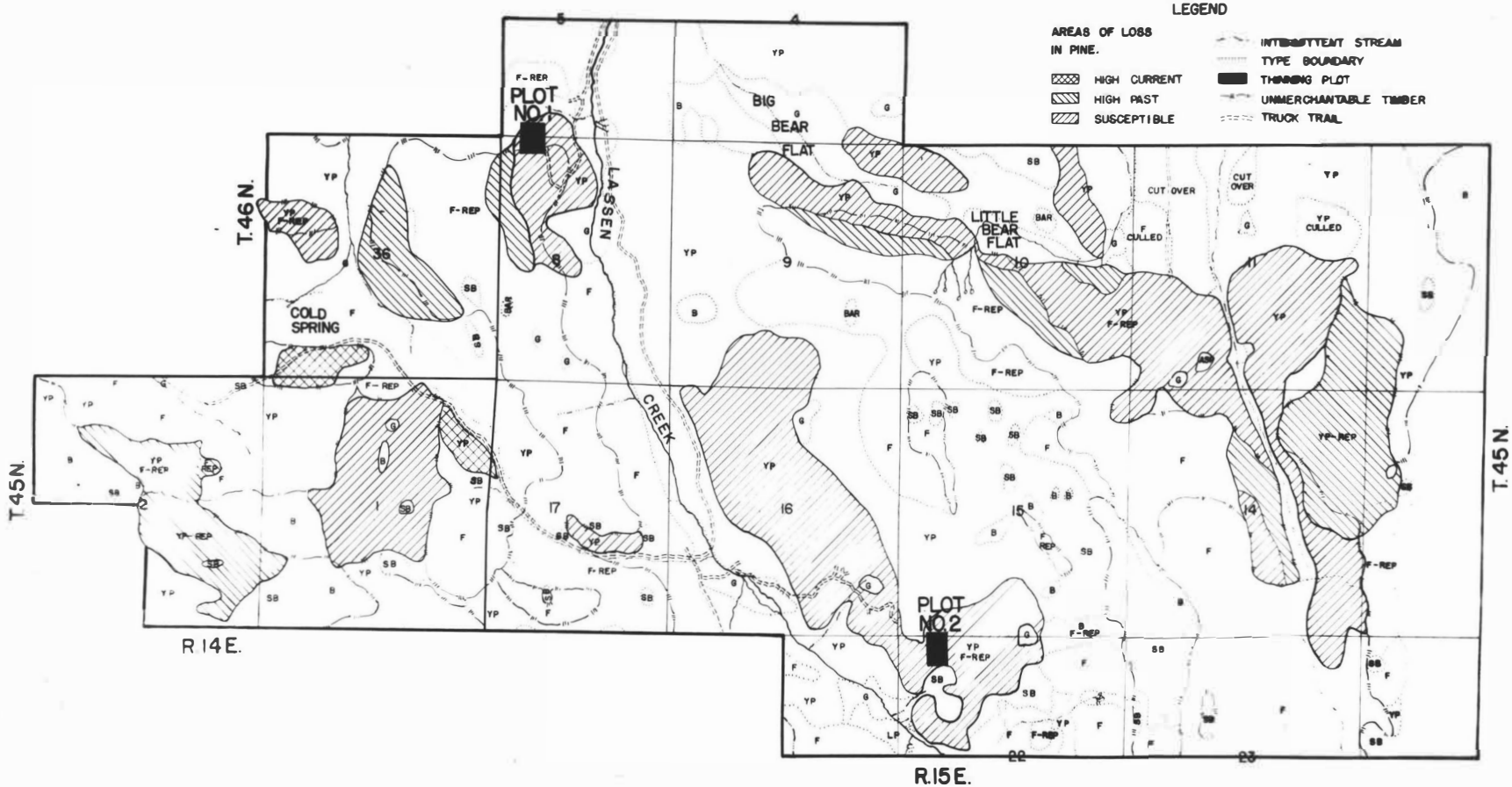


Figure 2. Mixed ponderosa pine - white fir type on west side of Lassen Creek. Darker crowns are fir. (110-44A)

Figure 3. Ponderosa pine poles killed by Dendroctonus monticolae. Surviving trees white fir. (110-45)

TABLE I

Summary of Stocking and Loss per Acre in Stands of

High Past Loss in Pine

D.B.H.	Ponderosa Pine			White Fir		Total
	Living	Current Loss	Past Loss	Living	Loss	
Inches						
4	11		87	102	30	
6	9	1	71	88	16	
8	4		48	51	9	
10	5		15	26	3	
12	4		5	9	2	
14	4		6	4	5	
16	4		1	4	2	
18	3				1	
20	1		1	1	1	
22	2			1	1	
24				1	1	
26	1				1	
28	1					
30	1					
Total	50	1	234	287	72	644
Percent	7.76	0.16	36.33	44.57	11.18	
Percent Species		44.25			55.75	
Percent Loss		0.35	82.11		20.06	47.67

TABLE II

Summary of Stocking and Loss per Acre in Stands of High Current Loss in Pine

D.B.H.	Ponderosa Pine			White Fir		Total
	Living	Current Loss	Past Loss	Living	Loss	
inches						
4	24	32	46	161	27	
6	30	37	41	92	11	
8	16	21	11	37	6	
10	17	11	3	21	2	
12	16	3	7	13		
14	11	3	1	10		
16	11	2		9	1	
18	2	1		2		
20						
22						
24	1					
26	1					
28						
30						
32	1					
Total	130	110	109	345	47	741
Percent	17.54	14.84	14.71	46.56	6.35	
Percent Species		47.10			52.90	
Percent Loss		31.52	31.23		11.99	35.90

TABLE III

Summary of Stocking and Loss per Acre in Stands

Susceptible to Loss in Pine

D.B.H.	Ponderosa Pine			White Fir		Total
	Living	Current Loss	Past Loss	Living	Loss	
inches						
4	16	2	6	38	6	
6	16		6	30	8	
8	5		4	15	3	
10	6		2	5	1	
12	2		1	4	1	
14	2		1	1	1	
16	3					
18	2			1		
20	1			1		
22	1					
24						
26	1					
28	1					
38	1					
Total	57	2	20	95	20	194
Percent	29.38	1.03	10.31	48.97	10.31	
Percent Species		40.72			59.28	
Percent Loss		2.53	25.32		17.39	21.65

From these tables it is apparent that prior to attack by mountain pine beetle all three areas had approximately the same proportion of pine and fir, although stands in which considerable loss has occurred were originally considerably more dense than stands which are now susceptible. This point is illustrated in figure 4 in which the percentage of pine originally present in each loss area is shown in comparison with that present in the 1938 stand.

A comparison of loss, based on the amount of each species present in the original stand, is illustrated in figure 5. This chart shows that from 10 to 20 percent of the fir has died in each area, whereas losses in pine higher than 80 percent have been sustained in heavily infested stands. Current loss in the latter is practically negligible. Areas of high current loss show a mortality in pine of over 60 percent, about evenly divided between current and past loss. Susceptible areas show a current loss in pine of about 2 percent, while past losses total about 25 percent. Due to similar losses in fir, the proportion of pine to fir is about the same in these stands. In all areas the losses in pine have been greater in the smaller diameters.

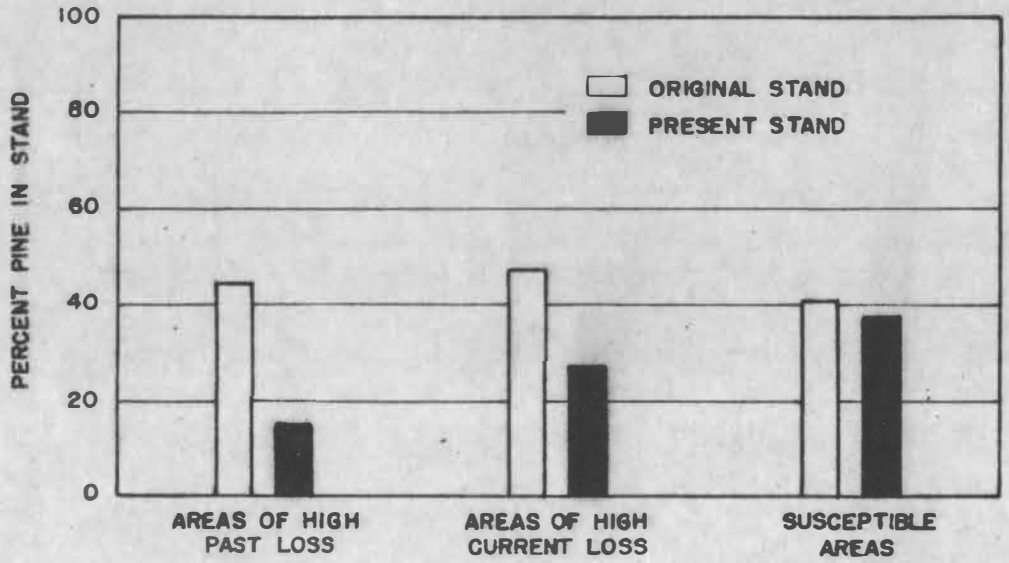
Figure 1 shows the location and relative proportion of each loss area. Intensive current activity of mountain pine beetle was found in only two small centers. In other localities infestations appear to be at a low ebb, although scattered groups of one to several trees containing brood occur fairly generally throughout all stands. Foci of past losses do not appear to bear any direct relationship to present centers of infestation, since susceptible areas were found adjoining areas of high past loss in several instances.

THINNING: AN EXPERIMENT IN INDIRECT CONTROL

The conversion of ponderosa pine - white fir stands to pure fir, through the activity of the mountain pine beetle in the Fandango area, is not resulting in the production of the most valuable crop the land is capable of supporting, if we can evaluate future timber crops by present standards. In an attempt to find a remedy for this situation in stands in which the pine has not yet been seriously depleted, an experiment was initiated this season to test the efficacy of thinning in favor of the pine as a means of indirect control. This experiment is predicated on the supposition that mountain pine beetle tends to select the weaker, less vigorous trees, particularly during periods when infestations are endemic. Thus, if more vigorous pine trees can be grown, it is expected that they will be less readily killed by this insect. It should be mentioned in passing that although intensive silvicultural measures similar to this are not now being applied in western forests, it is possible that such practices will be in effect by the time results of the present experiment are available.

Figure 4.

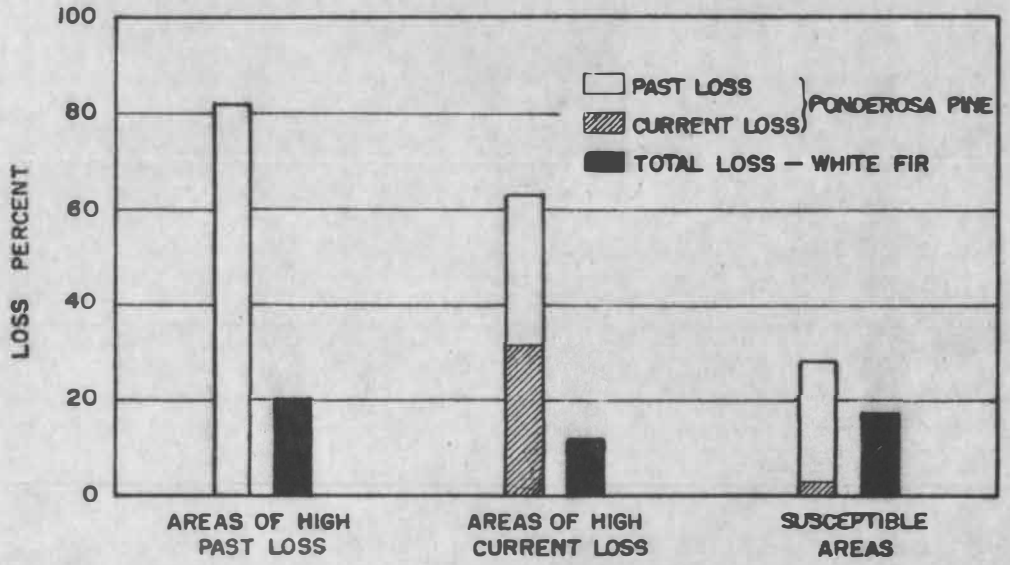
EFFECTS OF LOSSES* ON COMPOSITION
OF PONDEROSA PINE - WHITE FIR POLE STANDS



*BASED ON NUMBER OF STEMS PER ACRE ABOVE 4 INCHES D.B.H.

Figure 5.

COMPARISON OF LOSS* BY SPECIES
IN PONDEROSA PINE - WHITE FIR POLE STANDS



*BASED ON NUMBER OF STEMS PER ACRE ABOVE 4 INCHES D.B.H.

Methods

In an attempt to avoid some of the difficulties usually encountered in setting up thinning studies, the present experiment was designed to follow the reactions of the individual tree rather than the reactions of entire stands. This design permits the use of a much smaller number of trees, yields considerably more information, and should eliminate much of the variation found in plots set up on the conventional basis; however, it may be subject to some criticism from the stand point of the application of results.

Establishment of Plots

In the latter part of June two stands of mixed pine and fir on the Fandango Logging Chance were selected as sites for the thinning work. In each of these stands a rectangular plot between 7 and 8 acres in size was established, using a staff compass, Abney hand level, and 2 chain tape. Plot corners were marked with 1½ inch pipe set in concrete (figure 6), while all boundaries were brushed out and marked with paint "blazes". In addition, the north and south boundaries were staked at intervals of one chain with 2" by 2" squared cedar stakes (figure 7). A series of cruise lines tied in to these stakes were then laid out through each plot in a north-south direction. The cruise lines were also staked at intervals of one chain, and lightly brushed out and painted. A complete series of notes was carried in these surveys showing the distance and direction of the lines, together with elevations of all marked points. From these data a map of each plot was drawn up (figures 8 and 9).

With the framework of the plots laid out in this manner, the next step was to make a stand survey of the area within the plot boundaries. This was accomplished by making a tally by species, by 1 inch D.B.H. classes, of all trees living and dead above 2 inches D.B.H., on strips ¼ chain wide along each cruise line. A 25 percent stand cruise was obtained in this manner, the chief purpose of which was to determine whether or not the plots were comparable from the standpoint of composition and density.

Following the stand cruise 160 ponderosa pine trees which are considered crop trees were selected on each plot. This selection was based on the dominance of the tree, the number of competing stems, and the proximity of the tree to other selected trees. It was necessary to maintain a minimum distance of 28 feet between trees, due to the conditions of the experiment outlined below. An attempt was also made to secure a range of diameters and heights in the selection that would be representative of the entire stand. The crop trees were numbered with galvanized metal tags nailed at D.B.H. on the north side of the bole (figure 10). A white band of paint, 2 inches wide, was applied around the circumference of the stem just below the tag to facilitate the location of the tree in subsequent work. Later all trees were renumbered with a paint spray outfit (figures 11 and 12) to test the use of paint

Figure 6. Plot corner marked with iron pipe set in concrete. (110368)

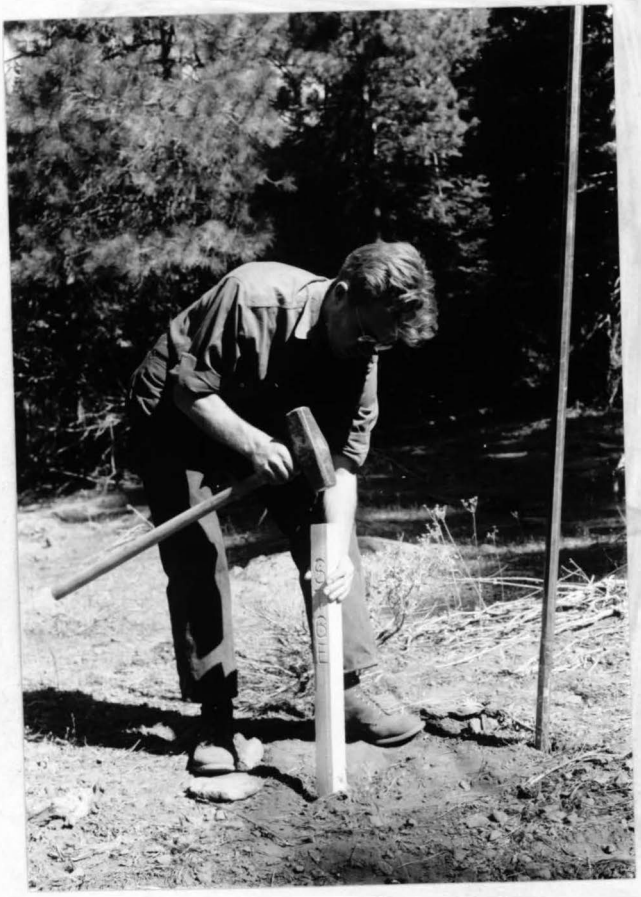


Figure 7. Cruise line marked with scribed cedar stakes set at intervals of 1 chain apart. (110369)

Figure 8

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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FANDANGO THINNING PLOT NUMBER ONE

MODOC NATIONAL FOREST

T. 46 N., R. 15 E., B.& M., MDM.

SCALE
Chains

CONTOUR INTERVAL 10 FEET

AREA 296 ACRES

JULY, 1938 C. B. EATON

LEGEND

PLOT BOUNDARY
CRUISE LINE
TYPE BOUNDARY
IRON PIPE
WOODEN STAKE
SUBPLOT
PONDEROSA PINE
WHITE FIR

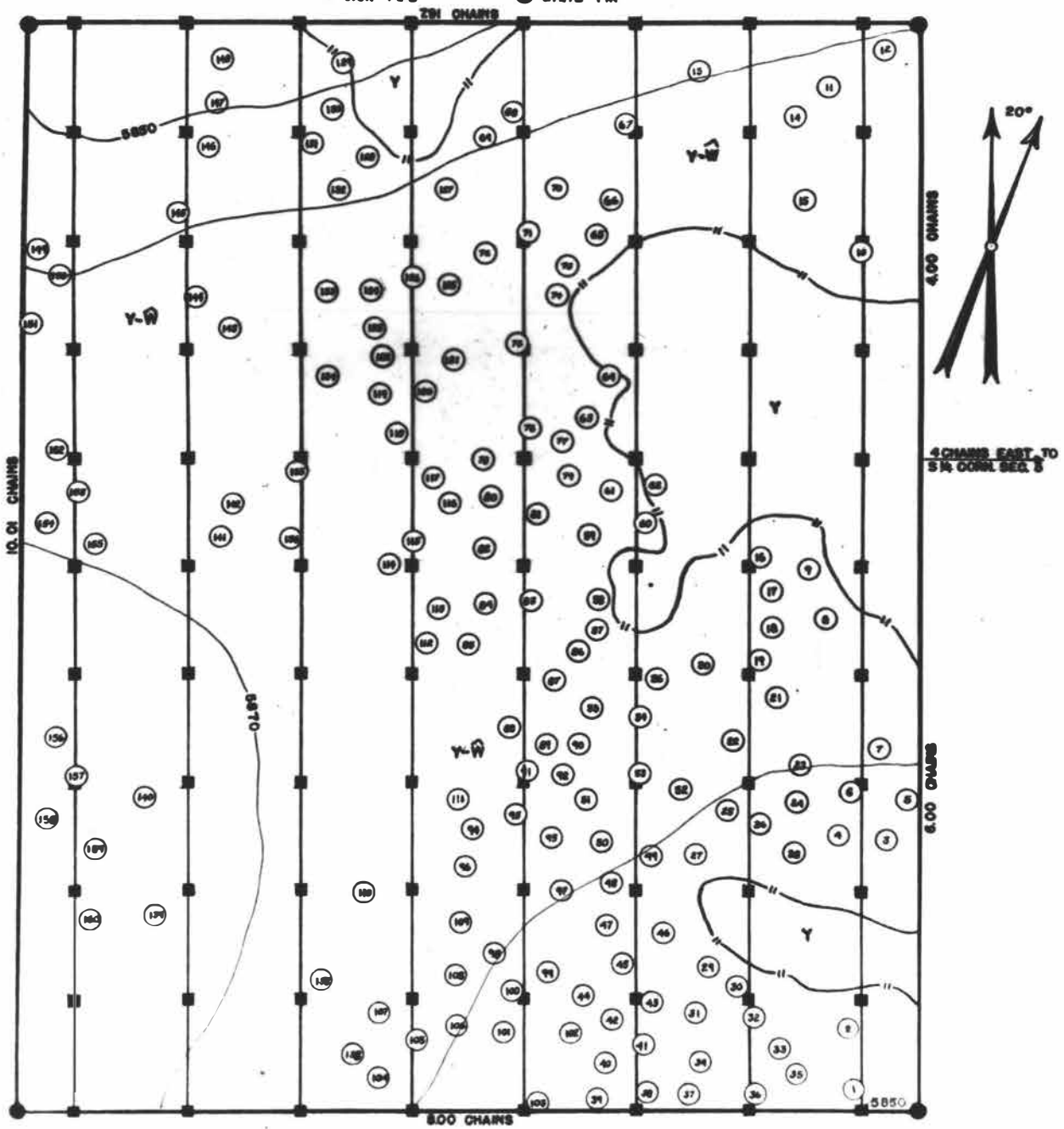

Figure 9

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FANDANGO THINNING PLOT NUMBER TWO
MODOC NATIONAL FOREST

T. 46 N., R. 15 E., S. 22., MDM

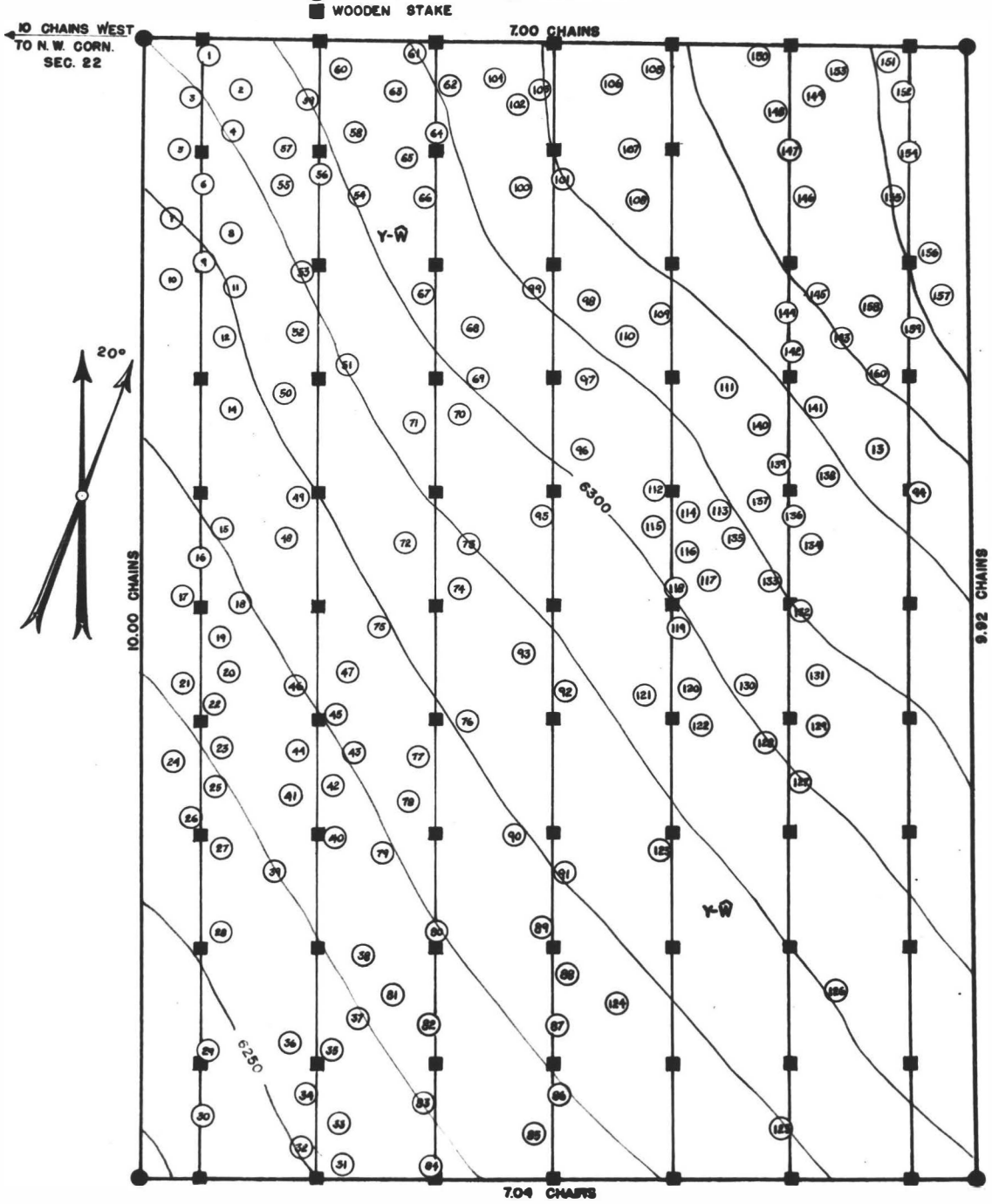
SCALE

CONTOUR INTERVAL 10 FEET
AREA 6.99 ACRES

JULY 1938 C. B. EATON

LEGEND

— PLOT BOUNDARY
— CRUISE LINE
● IRON PIPE
■ WOODEN STAKE
(24) SUBPLOT
(Y) PONDEROSA PINE
(W) WHITE FIR



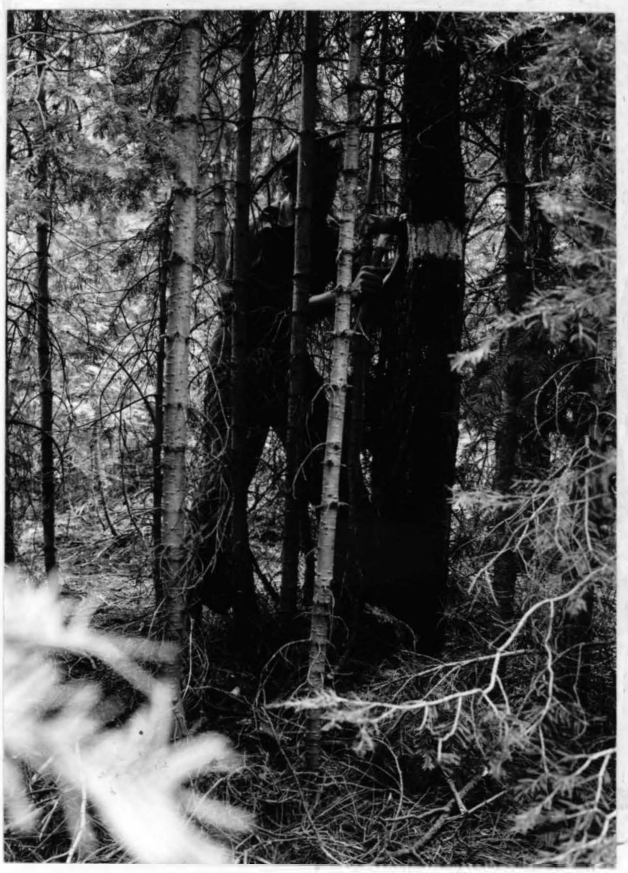


Figure 10. Numbering pine poles selected for release with metal tag. (11035J)

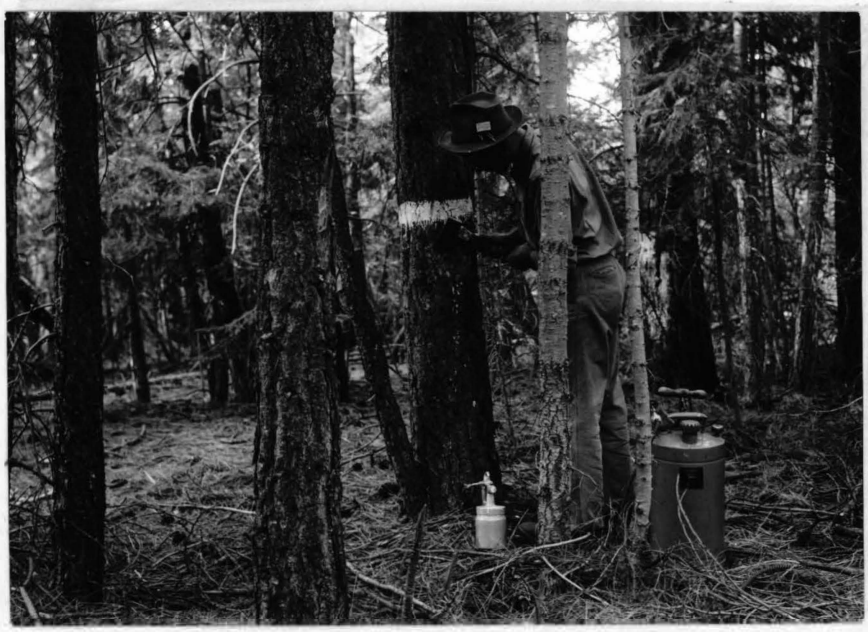


Figure 11. Smoothing bark in preparation for numbering tree with paint spray outfit. (11038D)

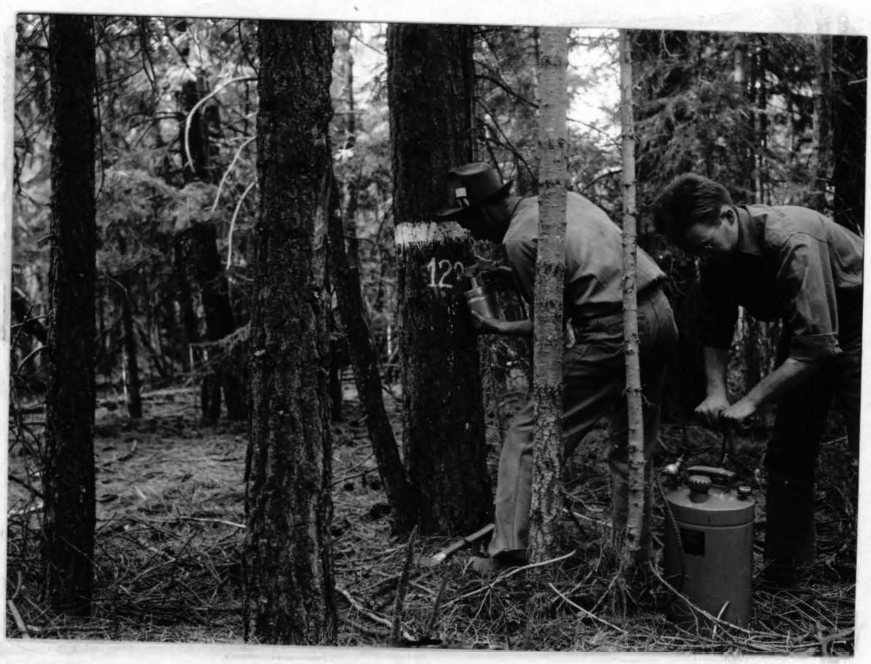


Figure 12. Numbering tree with paint spray outfit. (11038E)

numbers under western conditions, a method which seems to have received little attention by western investigators to date.

Measurements on Selected Trees

In order to determine the present condition of the selected trees, and to follow the changes which may take place as a result of the removal of competitors, detailed measurements and observations on the factors listed on the accompanying form (figure 13) were made prior to thinning. Evaluations of these factors were obtained in the following manner: D.B.H at the point where the metal tag is nailed to the tree was measured to the nearest two hundredths of an inch, (figure 14). Height was obtained through the use of an Abney hand level mounted on a light tripod (figure 15), and a tape for measuring horizontal distance from the instrument to the tree. Crown length, representing the distance between the point of attachment of the lowest green limb and the top of the tree, was computed by finding the distance from the limb to the ground and subtracting this value from the total height. For the smaller trees a measuring stick was used for this work (figure 16), but for the larger trees Abney readings were necessary. Crown width, representing the average diameter of the widest part of the crown, based on measurements of four radii, was obtained by means of an alignment rod and steel tape (figure 17). From visual examinations the general appearance, dominance, top shape, crown shape, crown density, twig injury, branch injury and stem injury for each tree were classified by the categories listed. Increment cores were taken at D.B.H. from all selected pines and from firs of similar size. Age counts for both species, and radial growth measurements by 10 year intervals for the pine were determined from the cores.

These measurements furnish a fairly complete picture of the individual crop tree as it would appear if isolated from surrounding trees. The concept is not complete, however, without taking the latter into consideration, for in the forest the number, location and size of competitors ordinarily influence the form and growth of the individual. In order to evaluate these factors, measurements on competitors were necessary, and to make these data comparable for all selected trees the measurements had to be confined to competing trees existing within a uniform unit of area. Accordingly, each selected tree was considered the center of a circular subplot, arbitrarily defined as having a radius of 14 feet. The number assigned to the central tree served as the number of the subplot. On each subplot all competing trees above 1 inch D.B.H. were mapped with a plane table, alidade and measuring stick (figure 18). Tree species, D.B.H. to the nearest tenth inch, and height estimated in fractions of the height of the central tree, were recorded on the back of the form referred to above in the manner illustrated in figure 19. In this manner records were taken on each of the 160 subplots established in each plot. This information was used as a basis for computing in terms of basal area, the amount of competition surrounding each selected tree before and after thinning.

Figure 13.

SHEET NO. _____ TREE NO. _____

FANDANGO THINNING EXPERIMENT
Modoc National Forest

Plot _____ Location _____ Strip _____ Tree Sp. _____

Treatment
Age

Killed by: Species Year
Brood: S W

DATE OF OBSERVATION					
OBSERVER					
D. B. H.					
HEIGHT					
CROWN LENGTH					
CROWN WIDTH					
APPEARANCE: Excellent					
Good					
Fair					
Poor					
DOMINANCE: Dominant					
Codominant					
Intermediate					
Suppressed					
TOP SHAPE: Acute					
Obtuse					
Rounded					
Flat					
CROWN SHAPE: Upper crown					
Upper mid					
Lower mid					
Lower crown					
CROWN DENSITY: Dense					
Medium					
Sparse					
TWIG INJURY: None					
Light					
Moderate					
Severe					
BRANCH INJURY: None					
Light					
Moderate					
Severe					
STEM INJURY					

Growth in inches by 10 year periods. (Count in)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Figure 14. Measuring D.B.H. with diameter tape. Note lower edge of tape just touches upper edge of tag. (110468)

Figure 15. Measuring height with Abney hand level, mounted with universal joint on light telescopic tripod. (110381)

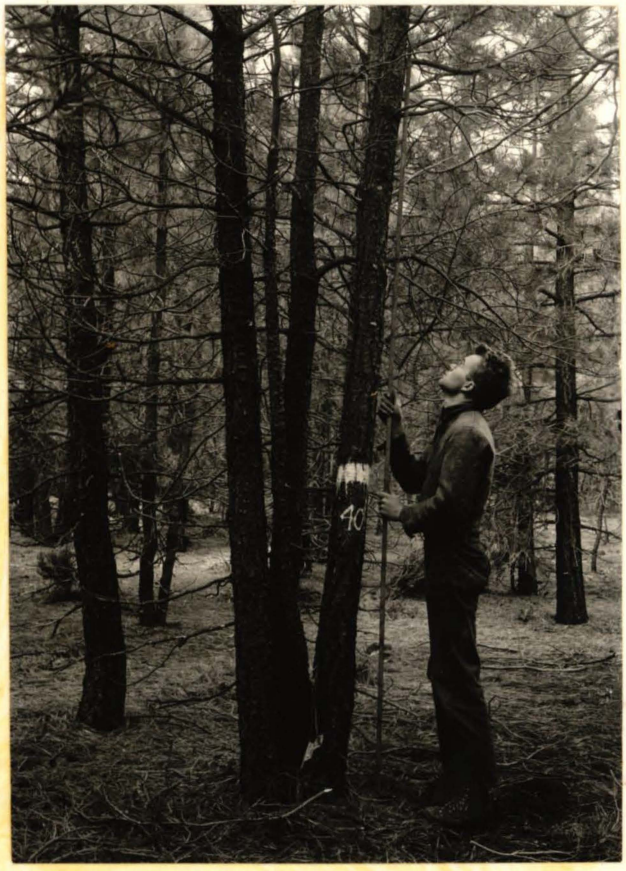


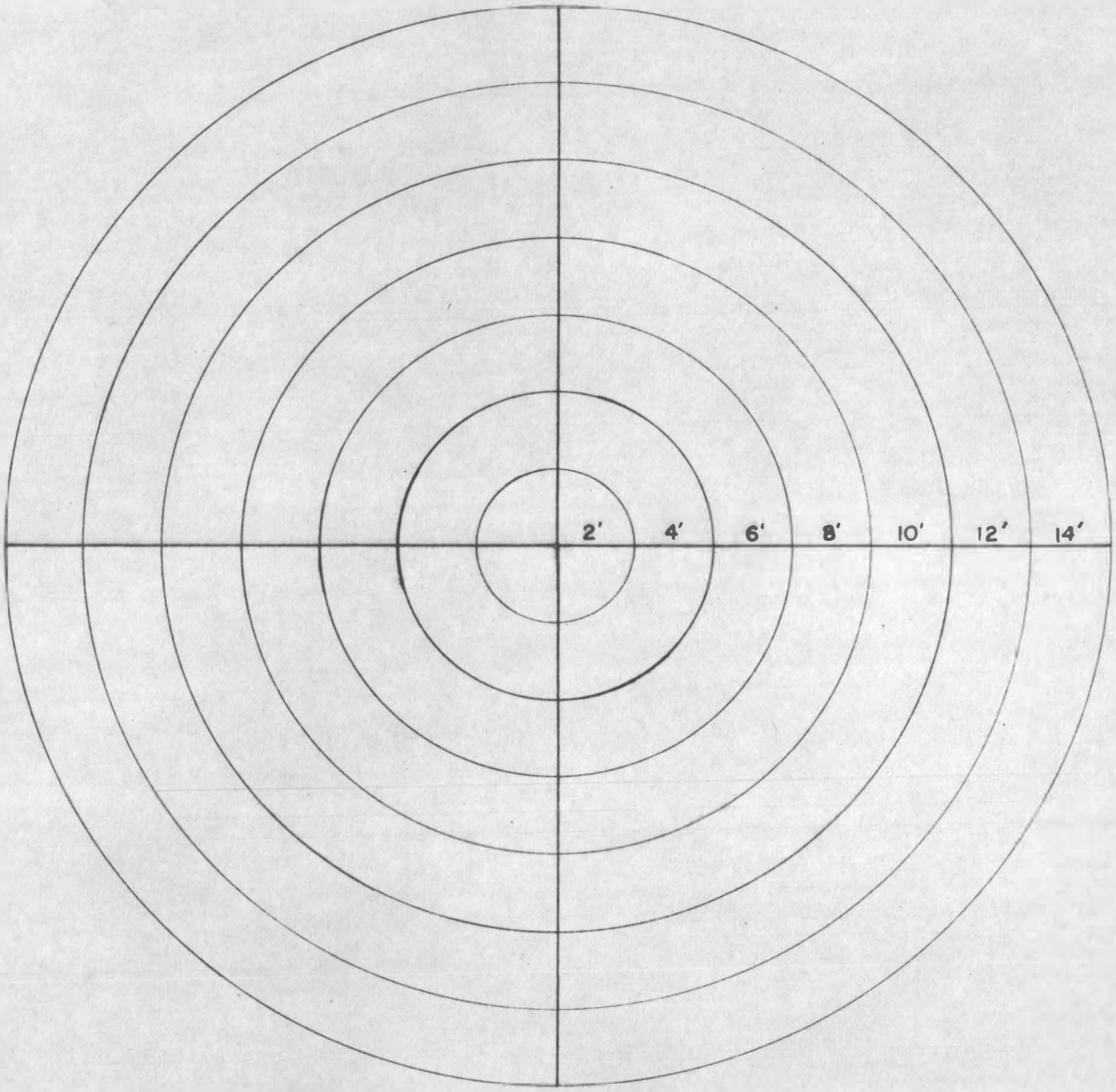
Figure 16. Measuring height to lowest green limb to get crown length. (110367)

Figure 17. Measuring crown radius with alignment rod and steel tape. (110366)

Figure 18. Mapping competing trees around pine poles selected for release. (110738A)

Figure 19.

SUBPLOT DATA SHEET



NO.	SP.	D.B.H.	HT.	NO.	SP.	D.B.H.	HT.	NO.	SP.	D.B.H.	HT.	NO.	SP.	D.B.H.	HT.

Thinning

The release of selected trees was based on the removal of competing trees occurring within arbitrarily defined radial limits. Four degrees of release were selected which permitted the allotment of 40 subplots per plot to each treatment. The magnitudes are as follows:

0 - check, no trees removed (figure 20)
4 - all trees removed within a radius of 4 feet (figure 21)
8 - all trees removed within a radius of 8 feet (figure 22)
12 - all trees removed within a radius of 12 feet (figure 23)

Thinning by these degrees resulted in the clearing of circular areas around each tree as follows: For the 4 foot treatment - 50 square feet, for the 8 foot treatment - 201 square feet, and for the 12 foot treatment - 452 square feet. Expressed as a proportion of the total area of each subplot, which is 616 square feet, the areas cleared are 8, 33 and 73 percent for the respective treatments.

The actual cutting was done in the latter part of October when the danger of insects being attracted to freshly cut logs and stumps is at a minimum. In this work the smaller firs and all the pines surrounding the crop trees were felled with axe and brush hook. Firs above 4½ to 5 inches D.B.H. were girdled, using the notch-girdling method. Felled trees were lopped so that the stems lay as close to the ground as possible, and the brush was scattered over the cleared area. Records were kept on the subplot maps of all trees removed in each treatment, including trees under one inch D.B.H. which had not been mapped.

Results of Current Work

It is obviously impossible at this early date to evaluate the success or failure of thinning in ponderosa pine - white fir stands as a means of controlling mountain pine beetle. A lapse of several years will be necessary before information on this, the main object of the investigation, will become available. However, analyses of some of the results of the season's work have uncovered considerable information concerning the character of mixed pole stands of this type, and the characteristics of the species involved. To aid in a more complete understanding of the problem, and to facilitate the future interpretation of the reactions of trees which have been released, a review of the basic data obtained in this season's work is presented herewith.

Plot Description

The two plots established this season have been designated as Fandango Thinning Plot Number 1 and 2 respectively.

Figure 20. Check treatment, unthinned. (11046A)

Figure 21. Four foot treatment. All trees within a radius of 4 feet removed or girdled. (11046B)

Figure 22. Eight foot treatment. All trees within a radius of 8 feet removed or girdled. (110460)

Figure 23. Twelve foot treatment. All trees within a radius of 12 feet removed or girdled. (11046D)

The first plot (figure 8) is located at an elevation of approximately 5850 feet, on a narrow bench of land at the base of an east slope. This plot is relatively flat in character, but dips gently to the southeast. Plot 2 (figure 9) is located at an elevation of approximately 6300 feet, on the west side of a ridge. This area slopes sharply to the southwest. Both plots are well drained and may be considered Site III for ponderosa pine. The soil is volcanic in origin, but well weathered with practically no rock outcroppings.

Stand Composition and Origin

Although the plots are comparable in that both are located in typical mixed stands of ponderosa pine - white fir poles, having a scattered overstory of overmature pine, minor differences exist between the two areas which are worthy of note. In Plot 1 there occur groups of pure pine older than the mixed pole stands, whereas Plot 2 supports only the latter. In the first plot these groups occupy 1.04 acres, or 13.07 percent of the total area. Logging activity around Plot 1 during the summer resulted in the removal of the bulk of the overmature trees. Cutting in the stand in which Plot 2 is located is expected in the near future. In arranging the thinning work, however, the subplots were chosen so that no considerable physical damage will result from the removal of these trees.

Differences also occur in the number and species of minor trees and shrubs growing in the two stands. The following list of secondary tree species found illustrates this point:

Plot 1	Plot 2
Juniper (Juniperus occidentalis)	Aspen (Populus tremuloides)
	Lodgepole pine (Pinus contorta)
	Serviceberry (Amelanchier spp.)

The absence of aspen on Plot 1 and its presence in considerable numbers on Plot 2 indicates that the site of the latter is probably more moist than that of the former.

Losses due to insect activity have occurred in both plots but have been so well distributed between the two species that the relative proportion of pine to fir is about the same. The chief losses in pine have been caused by mountain pine beetle, while those in fir are largely attributable to the fir engraver (Scolytus ventralis Lec.). At present both species are relatively inactive, but occasional trees containing brood can be found on both plots.

There is every indication that light fires have played an important part in the past history of the stands. Evidence serving as

a basis for this conclusion was found on both areas in the form of scars on overmature trees, scattered fragments of burned trunks and charred stumps. A few ring counts made on stumps in the logging area adjacent to Plot 1 show that fires of sufficient intensity to scar mature trees have occurred at periodic intervals during the life history of the stand. However, it was not possible with the limited data at hand to definitely affix the origin of the pine-fir understory to any one fire. Natural reestablishment of the species is so sporadic that this point may be easily obscured.

Stocking

To all outward appearances the stocking of pine-fir pole stands is much greater than that which the land is capable of profitably supporting. This observation is borne out by the results of the stand survey on the individual subplots, a summary of which is given in table 4.

TABLE IV

Summary of Stocking in Ponderosa Pine - White Fir Stands in Which Thinning Plots Are Located

Plot Number	Trees per acre Under 1 inch DBH		Trees per acre Over 1 inch D.B.H.		Total Trees per acre	
	Number	Basal area Sq. ft.	Number	Basal area Sq. ft.	Number	Basal area Sq. ft.
1	1532	2.145	1836	159.261	3368	161.406
2	3530	4.942	2342	167.057	5872	171.999

The diameter range covered by these data is from ½ to 20 inches D.B.H., though the great majority of the trees fell within the smaller diameter classes. While these data alone do not give much of a basis for evaluating present stand density in terms of what is optimum for the site, it seems obvious that the stand is overstocked.

In comparison to the average stocking of pine-fir pole stands extant in the Fandango Logging Chance, the two areas in which plots are located are somewhat more dense. In this respect they are more nearly comparable to stands in which high losses have occurred, than to existing stands classified as susceptible.

From the standpoint of distribution of the two main species, the stands differ. In Plot 1 there are about 2 pines to every fir, whereas in Plot 2 the situation is reversed. Minor tree species are so rare that they form an insignificant part of the stand.

A summary of the average stocking per subplot before and after treatment is shown in table 5. From these data it is evident that the subplots used in each treatment were quite comparable in respect to the number of stems, basal area and ratio between species. Thinning did not appreciably change the latter, but considerably reduced the number of stems and basal area per subplot. Reduction in competition brought about by the various treatments was 16 percent for the 4 foot thinning, 33 percent for the 8 foot, and 70 percent for the 12 foot. The reduction is roughly proportional to the area cleared, although the release accomplished by the 4 foot treatment is relatively large.

Age

Ring counts on increment cores from trees ranging from 3 to 16 inches D.B.H. show that the pine and fir occurring in pole stands have approximately the same age distribution, although the fir is slightly younger than the pine (table 6, figure 24). These data also show that a fairly wide range of age classes is represented in pole stands, although in respect to the older growth the stands may be considered even-aged. The D.B.H. and height by age class for the pine trees selected for release varied considerably (table 7), but the relation of mean D.B.H. to age, (figure 25), and mean height to D.B.H. (figure 26), are characteristic of all-aged stands. In actuality the stands are even-aged in groups, with the majority of the trees falling in two distinct age classes: one at 35 years and the other at 55 years. This condition is interpreted as being the result of a combination of circumstances favoring the establishment of seedlings at these two periods.

Growth Rate

In order to determine the present growth rate of the pine in pine-fir pole stands, and to check up on past growth performance as a measure of the site capabilities, detailed analyses were made of increment cores from all trees selected for release. In working up these measurements it was necessary to segregate the different age classes, since the variation in growth rate between trees of different ages would tend to obliterate growth trends due to other factors. The results of these analyses are summarized in table 8 and figure 27. As expected, these data show that the older trees are growing at a slower rate than the younger trees. However, it also appears that within the same age class the growth rate has taken a sharp drop during the last few decades.

There are several factors contributing to the slowing up of growth in these stands, but perhaps the two most important are: (1) rainfall deficiency, and (2) excessive competition. Weather records taken at Lakeview, Oregon, about 25 miles north of the Fandango Logging Chance, show that the rainfall has been below normal during the past three decades. At the same time competition has become more and more intense with the increase in the age of the stand. The condition which has resulted indicates a gradual weakening of the trees, and may help explain their susceptibility to mountain pine beetle.

TABLE V.

Summary of Average Stocking per Subplot Before and After Thinning*

Radius of Area Cleared feet	Stocking before Thinning: Number of Trees W.F.	P.P.	Total	Basal Area Sq. ft.	Stocking after Thinning: Number of Trees W.F.	P.P.	Total	Basal Area Sq.ft.	% of Original
Plot No. 1									
0	8.2	16.9	25.1	2.300					
4	8.6	17.0	25.6	2.214	7.2	14.2	21.4	1.893	85.50
8	7.7	17.1	24.8	2.491	4.8	10.4	15.2	1.708	68.57
12	8.3	16.1	24.4	2.004	2.1	2.9	5.0	0.576	28.74
Plot NO. 2									
0	24.0	9.0	33.0	2.280					
4	23.4	9.2	32.6	2.426	19.8	8.2	28.0	2.042	84.17
8	21.6	9.0	30.6	2.365	13.6	5.0	18.6	1.528	64.61
12	23.6	9.1	32.7	2.379	5.0	2.3	7.3	0.708	29.76

* Based on 320 circular subplots, each having an area of 616 sq. ft. Includes all trees 1" D.B.H. or larger.

Figure 24.

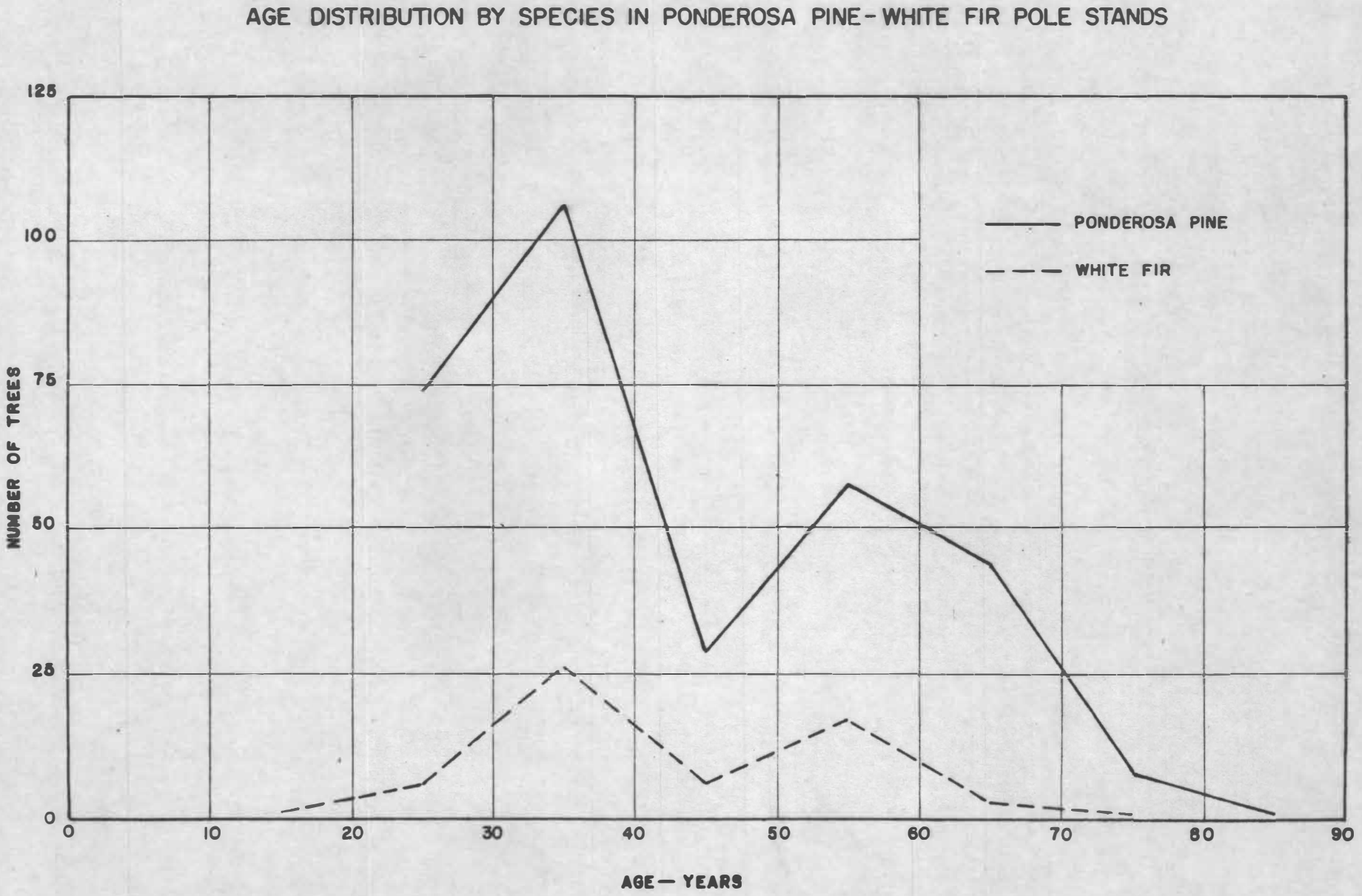

AGE DISTRIBUTION BY SPECIES IN PONDEROSA PINE-WHITE FIR POLE STANDS
125
100
75
50
25
0
NUMBER OF TREES
0
10
20
30
40
50
60
70
80
90
AGE— YEARS
PONDEROSA PINE
WHITE FIR

TABLE VI

Age Distribution by Species in Ponderosa Pine - White Fir Pole Stands*

Age Class	Plot No. 1		Plot No. 2		Both Plots	
	P.P.	W.F.	P.P.	W.F.	P.P.	W.F.
years						
10-19		1				1
20-29	6	3	68	3	74	6
30-39	63	6	43	20	106	26
40-49	19	3	10	3	29	6
50-59	29	11	29	6	58	17
60-69	34	1	10	2	44	3
70-79	8			1	8	1
80-89	1				1	
Total	160	25	160	35	320	60
Mean Age	48	44	47	41	48	42

* Based on ring counts on cores from trees 3 to 16 inches D.B.H.

TABLE VII

Summary of Mean Diameter and Mean Height by Age Class

for Ponderosa Pine Poles Selected for Release

Age Class	Plot No. 1			Plot No. 2			Both Plots		
	Number Trees	Ave. DBH	Ave. Height	Number Trees	Ave. DBH	Ave. Height	Number Trees	Ave. DBH	Ave. Height
years		in.	ft.		in.	ft.		in.	ft.
20-29	6	5.08	26				6	5.08	26
30-39	63	5.71	27	68	5.07	23	131	5.38	25
40-49	19	6.29	32	43	7.04	33	62	6.81	33
50-59	29	7.06	37	10	8.85	44	39	7.52	39
60-69	34	8.76	44	29	9.76	48	63	9.22	46
70-79	8	9.81	52	10	10.17	50	18	10.01	51
80-89	1	16.30	69				1	16.30	69
Average		6.92	34		7.01	33		6.97	34

Figure 25.

RELATION OF D.B.H. TO AGE FOR PONDEROSA PINE POLES IN MIXED PINE-FIR STANDS

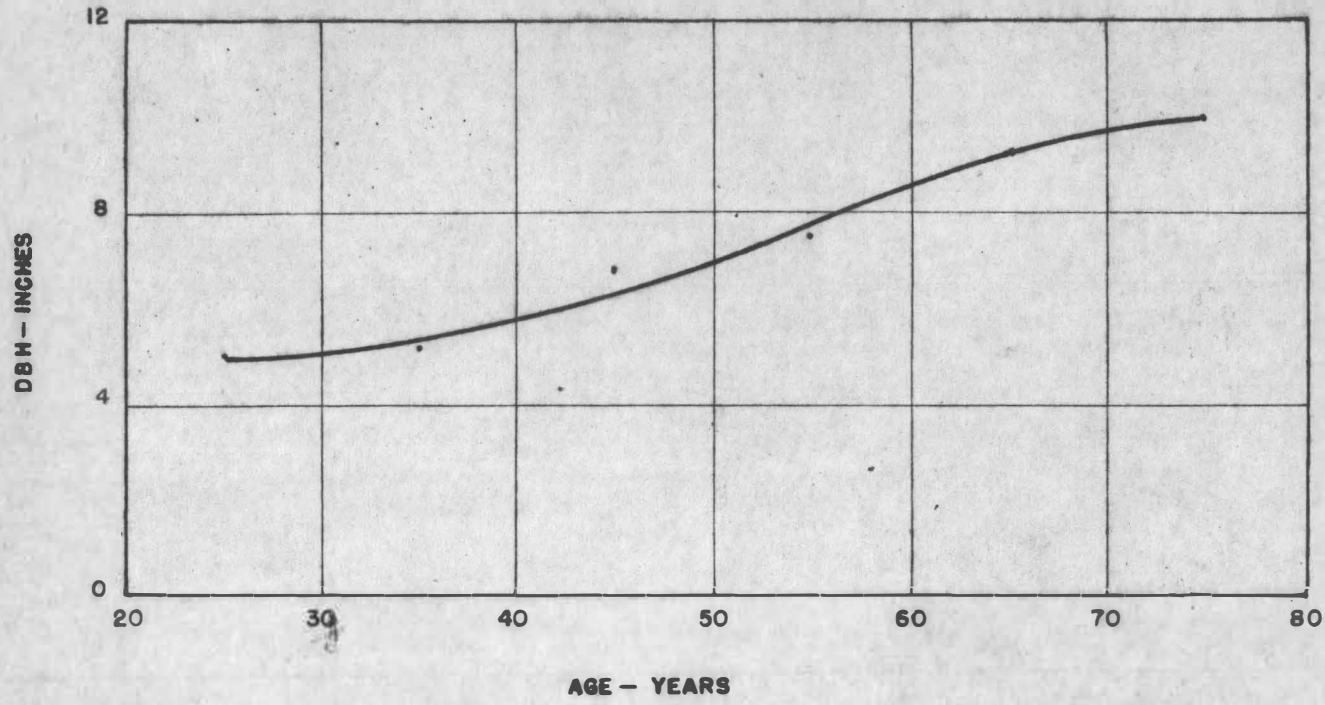


Figure 26.

RELATION OF HEIGHT TO D.B.H. FOR PONDEROSA PINE POLES IN MIXED PINE-FIR STANDS

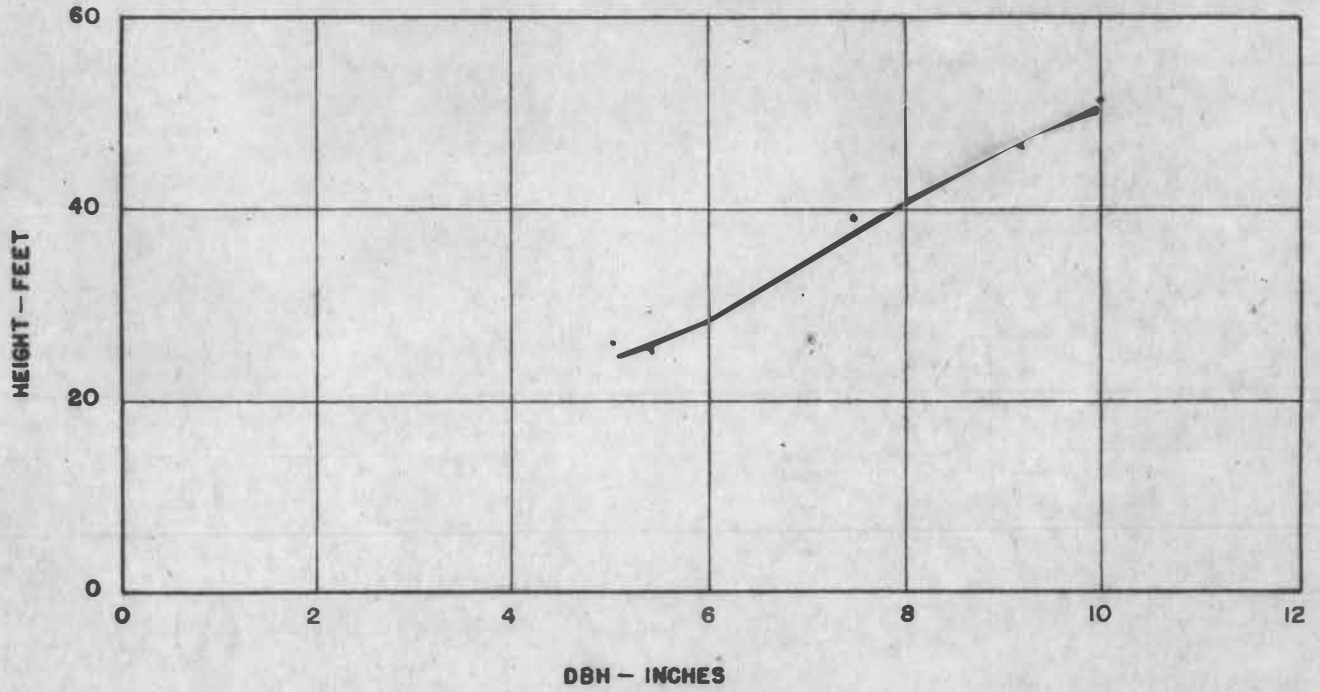


Figure 27.

PERIODIC GROWTH OF 35-YEAR OLD PONDEROSA PINE POLES

DURING PAST 5 DECADES

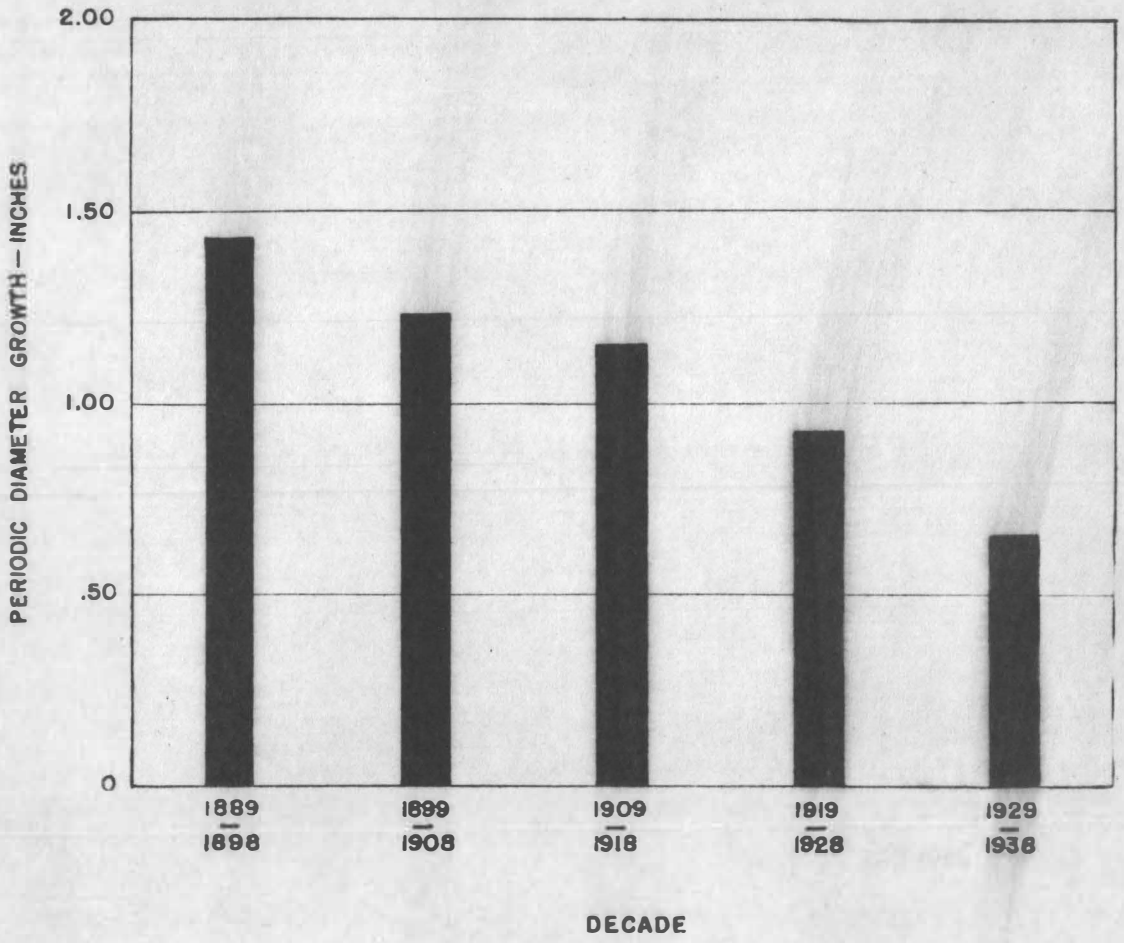


TABLE VIII

Summary of Mean Diameter Growth in Different Decades

for Ponderosa Pine Poles of the Same Age Class*

Age Class	Mean Diameter Growth by Decades						
	1869 1878	1879 1888	1889 1898	1899 1908	1909 1918	1919 1928	1929 1938
years	inches	inches	inches	inches	inches	inches	inches
15	1.88	1.76	1.70	2.04	1.90	1.58	
25		1.54	1.54	1.52	1.70	1.06	0.84
35			1.42	1.34	1.28	0.92	0.66
45				1.12	1.10	0.68	0.54
55					0.90	0.64	0.42
65						0.50	0.42
75							0.34

* Based on measurements on 319 trees ranging from 20 to 80 years in age.

Future Investigations

The work of the current season has been largely a matter of laying the ground work of the experiment. The excessive competition around crop trees has been relieved to varying degrees. It remains to be seen whether or not the mountain pine beetle endemic to these areas will continue its attacks irrespective of the treatments, or whether the unthinned checks will be killed first, while the thinned trees survive. While the most time consuming part of the experiment has been completed this season, a certain amount of follow-up work will be necessary subsequently. Recommendations are as follows:

1. During the season of 1939 a study should be made in stands of high current loss to determine whether or not there is any correlation between growth rate of pine poles and susceptibility to attack by mountain pine beetle.

2. Also during the season of 1939 a map should be made showing the location of current infestations on each plot. This map should be revised at 5 year intervals.

3. In the spring of each year an examination of the selected pine trees should be made to determine the extent of mountain pine beetle attacks in the various treatments.

4. Records should be kept each season showing the maintenance necessary on each plot. These notes should cover line clearance, stakes, adjustment of metal tags and repainting paint numbers.

5. At 5 year intervals detailed remeasurements of the crop trees, and remapping of the existing stand on each subplot should be made. The objectives of this work would be to determine the changes in characteristics of the treated and check trees, success of establishment of reproduction in cleared portions of subplots, and changes in the competing stand with respect to trees growing up to and above the minimum diameter limit, together with mortality in the present stand.

SUMMARY

During the season of 1938 investigations were begun on the Modoc National Forest to determine the extent of losses caused by mountain pine beetle in ponderosa pine - white fir pole stands, and to test the value of thinning as a means of indirectly controlling the insect.

Strip cruises made over an area of 8640 acres in the Fandango Logging Chance show that 2140 acres were originally covered by the ponderosa pine - white fir pole type. An area of 598 acres of this type

has been converted to almost pure fir through the past activity of mountain pine beetle. Currently this insect is active on 54 acres. Stands of similar composition, but not nearly so dense as the infested areas, occur on 1488 acres.

On the supposition that the mountain pine beetle tends to select the weaker, less vigorous trees, an experiment in indirect control was set up in which 120 crop trees on duplicate plots were thinned in such a manner as to provide three degrees of release i.e., competing trees within radii of 4, 8 and 12 feet of the crop trees were removed. Untreated controls were also selected.

The stands in which this experiment is being conducted are located on fairly good sites, and having the following characteristics:

1. Composition. The stands are practically entirely composed of ponderosa pine and white fir poles, overtopped by widely scattered, overmature pine.

2. Stocking. There are between 3500 and 6000 trees to the acre ranging from $\frac{1}{2}$ to 20 inches D.B.H. The majority of the trees are in the smaller diameters.

3. Age. The trees are even-aged in groups, the majority falling into two distinct age classes: 35 and 55 years. There is no appreciable difference in the age of the two species.

4. Growth Rate. The pine, though generally dominant, is growing at an abnormally slow rate, apparently due chiefly to excessive competition and a deficiency in available moisture.

In order to evaluate the use of thinning as a means of preventing mountain pine beetle attack in pine-fir pole stands, continued observations on the released trees will be necessary over a period of several years.

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